

THE WHALE PROBLEM  
" "  
A Status Report

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CHAPTER 6

WHALES AND WHALE RESEARCH IN THE EASTERN NORTH PACIFIC

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In an earlier review of Pacific coast whaling and whale research (Rice 1963), I wrote that "the southern hemisphere stocks of baleen whales have continued to decline at an accelerating rate. . . . Fleets of factory ships and catcher boats represent a capital investment of millions of dollars. If they can no longer operate at a profit in the Antarctic, some of them may turn to the North Pacific."

From 1954 through 1961, the number of floating factories operating in the North Pacific remained at three, and the number of whales killed—including those taken by 24 to 30 shore stations—varied between 8,000 and 13,000. By 1963 the number of floating factories had increased to seven. The number of whales killed increased each year, reaching a peak of 24,150 in 1968. By 1967, the North Pacific had surpassed the Antarctic as the world's major whaling ground, and during the two seasons 1969 and 1970 the North Pacific catches have been almost double those of the Antarctic.

The most recent phase of whaling in the United States began in 1956 when the Del Monte Fishing Company established a shore station on San Francisco Bay at Point San Pablo, in Richmond, California. In 1958 a second station was established on the point by the Golden Gate Fishing Company. The latter closed in 1966. The catch at these stations (Table 6-1) has consisted mainly of fin, sei, humpback, and sperm whales, along with a few blue, giant bottlenose, and killer whales. The highest annual catch was 338. A company in Astoria, Oregon, took 13 whales between 1961 and 1965. The United States catch has constituted only 0.4 to 3.2% of the total North Pacific catch.

TABLE 6-1. Number of whales taken by California shore stations, 1956-1970.

Season	Shore stations	Catcher-boats	Number of Whales						
			Blue	Fin	Sei	Hump-back	Sperm	Giant bottlenose	
1956	1	3		3		133	9	145	
1957	1	3		22	1	199	14	1	237
1958	2	4	26	109	2	115	8	1	261
1959	2	5	5	108	37	140	17	2	309
1960	2	5	1	138	47	67	16	2	271
1961	2	5	2	118	51	62	101	4	338
1962	2	5	2	123	22	39	60		247 <sup>a</sup>
1963	2	5	6	17	96	55	77	1	253 <sup>a</sup>
1964	2	5	2	148	13	27	63	1	254
1965	2	5	4	114	22	4	97	2	243
1966	2	5		42	62		69	1	175 <sup>a</sup>
1967	1	3		44	3		101		150 <sup>b</sup>
1968	1	3		38	14		84		136
1969	1	3		31	10		68		109
1970	1	3		6	4		64		73

<sup>a</sup> Includes one killer whale.<sup>b</sup> Includes two killer whales.

#### Review of Research

##### History and Methods

In 1958 a research program on the larger species of whales was undertaken by the Marine Mammal Biological Laboratory of the former Bureau of Commercial Fisheries (since October 1970, the National Marine Fisheries Service). The objectives of this program (Rice 1963) were to determine the basic features of the life history and ecology of each species, to define the geographical distribution and migrations of each stock, and to ascertain the size and sustainable yields of each stock.

Research methods have included (1) examination of the whales

brought into the shore stations; (2) marking of whales from chartered catcher boats; (3) observations of living whales from vessels and from shore; and (4) analysis of catch statistics.

Beginning in 1959, a biologist has been on duty at the whaling stations throughout most of each season. In 12 years 2,191 whales have been examined (Table 6-2). This number includes 73% of the whales taken during the regular whaling season, plus 316 gray whales taken in winter under special scientific permits.

TABLE 6-2. Number of whales examined at California shore stations, 1959-1970.

Species	Males	Females	Total
Blue	7	13	20
Fin	325	357	682
Sei	101	183	284
Humpback	129	105	234
Gray	166	150	316
Sperm	392	245	637
Giant bottlenose	13	0	13
Killer	4	1	5

At the whaling stations, data routinely recorded for each whale include body length, sex, date and locality of capture, blubber thickness, condition and depth of mammary gland, diameter of uterine cornua, sex and length of fetus, weight of testes, species and quantity of food in stomach, species and numbers of ectoparasites and endoparasites, and degree of fusion of vertebral epiphyses. Material collected for further analysis in the laboratory includes the ovaries, the ear plugs of baleen whales and the teeth of sperm whales (for age determination), histological specimens of the testes, uterus, and mammary glands, samples of the stomach contents and parasites, and pathological specimens. A detailed description of procedures has been published by Rice and Holman (1971).

A whale marking program was instituted in 1962 (Table 6-3). We have done most of our marking during the winter in the area between

## WHALES IN EASTERN NORTH PACIFIC

TABLE 6-3. Number of whales effectively marked, and number of marked whales recovered, 1962-1970.

Species	Number marked	Number recovered	Remarks
Blue	76	0	Protected since 1966
Fin	56	8(14%)	
Sei	10	3(20%)	
Bryde's	19	0	Unexploited stock
Humpback	44	0	Protected since 1966
Gray	5	0	Protected
Sperm	176	3(2%)	
Total	386	13	

San Francisco ( $38^{\circ}\text{N}$  latitude) and the Islas Revillagigedo ( $19^{\circ}\text{N}$  latitude), so that we can determine which breeding stocks contribute to the populations that are exploited on the various summer grounds.

All observations of whales—as well as other marine mammals—made during the marking cruises have been recorded in detail: species, date and time, position, number in group, and any other pertinent information such as digestion of travel, behavior, feeding, and presence of calves. The approximately 5,000 sightings of about 100,000 individuals provide considerable data on the distribution and relative abundance of 26 species of cetaceans and 9 species of pinnipeds. Since the taking of blue and humpback whales was banned, the catcher-boat captains have been logging all sightings of these species during whaling operations; these records, if maintained through the years, will provide information on population trends in these species. Counts of migrating gray whales are regularly made from shore, and migrating bowhead whales have been counted from the ice edge. Aircraft have also been used to a limited extent to observe the latter two species.

Statistics of the whaling industry are the most detailed available for any fishery. The species, sex, body length, and date and position of capture are on record for virtually all of the whales taken in postwar years. Detailed effort data are also on record. Except

for catches off Baja California, the prewar statistics for modern-style whaling in the eastern North Pacific are not as complete, but records are available of the total number of whales of each species taken each year by most stations. The major gap in the record is in the California statistics for the years 1930 to 1936, which give annual totals, but do not record the species. For the old-style American fishery for sperm and right whales, from 1784 to 1935, the area of operation and the production of sperm oil, whale oil, and whalebone for each voyage have been recorded (Starbuck 1878; Hegarty 1959). Townsend (1915) examined the logbooks from 1,665 old-style whaling voyages and prepared a classic series of charts on which were plotted, by month, the positions where 53,677 sperm, right, humpback, and bowhead whales were killed. Meany (1851) had earlier prepared a similar but less detailed chart for sperm and right whales. These long series of detailed statistical data, when analyzed in the light of our biological knowledge of whales, provide an unusually detailed picture of past and current trends in whale populations.

Since whales wander widely over the high seas, and each stock may be exploited in several parts of its range and by more than one nation, research objectives cannot be fully met by a study confined to one portion of the range of a stock. In 1962, just prior to the rapid expansion of the North Pacific whale fishery, at the urging of the late Remington Kellogg, then United States Commissioner to the International Whaling Commission (IWC), the Scientific Committee of the IWC appointed a North Pacific Working Group consisting of biologists and mathematicians from the four nations then engaged in whaling in the North Pacific—Canada, Japan, the Soviet Union, and the United States. This group was asked to coordinate national research efforts, to exchange data, and to determine the sustainable yields of each stock of whales.

Data on catch, effort, and length-frequency distribution for the postwar years were exchanged in 1964, and data for subsequent seasons have been exchanged annually. Catch data include the number of whales of each species and sex taken during each month in each 10-degree square of latitude and longitude. Effort data include the horsepower and tonnage of each catcher-boat and the number of days that it hunted

in each 10-degree square each month. Length-frequency data for each species and sex are reported for each 20-degree zone of longitude. Data on the number of whales effectively marked each year in each 10-degree square, and full particulars on all recoveries of marked whales, are exchanged. (A whale is considered "effectively" marked if the mark is entirely imbedded in it.) Certain other tabulated biological data have been made available by each country. These data have included age/length keys based on counts of growth layers in ear plugs or teeth, and on counts of corpora albicantia in the ovaries.

This exchange of data has enabled mathematicians from each country to make independent estimates of population sizes and sustainable yields of each stock of whales.

#### Accomplishments

The rorquals (blue, fin, sei, and humpback whales) received priority in our research efforts in the early 1960's because they are more vulnerable to overexploitation than are sperm whales. We have in preparation a comprehensive report on the life history and ecology of the rorquals in the eastern North Pacific. The basic features of the biology of the rorquals—especially fin and humpback whales—throughout their ranges are fairly well known, and population assessment methods are well established. The North Pacific Working Group's assessments convinced the IWC of the need for extending complete protection to blue and humpback whales, beginning in 1966. The group's estimates of the sustainable yields of fin and sei whales led to the imposition of catch limits on these two species for the first time in 1969.

Sperm whales, the most important species in the North Pacific fishery, are more abundant and far more widely distributed than the baleen whales, but they present more complex management problems. Because of their polygyny, marked sexual dimorphism in size, and partial geographical and social segregation of the sexes, sperm whale catches consist of about 75% males, almost all adult; only a few of the older females are killed. Until recently, knowledge of the reproductive cycle and social behavior of the sperm whale was sketchy.

The Scientific Committee of the IWC recommended that special scientific

permits be issued for taking sperm whales under the legal length limit, so that samples of females and younger males could be studied. Since 1966 the United States has taken 109 sperm whales under special scientific permits. A preliminary report on our sperm whale studies was submitted to the special meeting on sperm whale biology convened by the IWC Scientific Committee in March 1970, and a full report will soon be published. Intensive sperm whale research has also been conducted in many other parts of the world during the past 20 years. Our understanding of the biology of this species is now reaching the point where we should soon be able to prescribe rational management regulations.

Studies on protected species have also been undertaken. A monograph on the life history and ecology of the gray whale was recently published (Rice and Wolman 1971). Soviet biologists have also studied the reproductive cycle and parasites of gray whales taken by natives in the Bering and Chukchi Seas (for example, Zinushko 1969). I spent April and May of 1961 and 1962 in Eskimo whaling camps near Point Hope and Barrow, Alaska, to study bowhead whales. Because of problems of logistics and communications, and the small number of bowheads taken, further expenditure of our limited time and money did not seem justified. The bowhead remains the least-studied species of large cetacean.

#### Status of Species

The following accounts include all nine of the species of baleen whales that occur in the eastern North Pacific, plus the two largest species of toothed whales. I have briefly summarized what is known of the distribution and movement of each species, and its population size and trends. Most species of baleen whales appear to have a tendency to migrate more in coastal than in mid-ocean waters, so the concept of more or less discrete eastern and western North Pacific breeding stocks is reasonable pending further results from marking programs, blood-type studies, etc. Sperm whales range widely over the oceans, and separate stock units cannot be discerned until more marked animals are recovered.

##### Blue Whale (*Balaenoptera musculus*)

Distribution. One of the world's last remaining sizable stocks

of blue whales congregates from February to early July each year along the west coast of Baja California. The presence of blue whales in these waters was known to nineteenth-century whalers, who rarely tried to capture them because they were too swift to pursue and kill with open boats and hand harpoons or bomb-lances. One of the few who tried and succeeded was Captain Seaman (1874), who wrote:

Several days trial were made in the brig Boston, in 1858, off Cedros [- Cedros] Island, to capture these animals. It was in the month of July, and the sea, as far as the eye could discern, was marked by their huge forms and towering spouts. . .

On a second voyage of the Page, six of these immense creatures were taken by the bow-gun and lance, off the port of San Quintin, Lower California, where the moderate depth of water was favorable for their pursuit. Large numbers of them were found on this ground, where they had been attracted by the swarms of sardines and prawns. . .

The whales in this area were first exploited by whalers using modern methods in the winter of 1913 and 1914, when three catcher-boats operating from the floating factory Capella I killed 83 of them (Tversen 1967). Ingabritsen (1939) wrote:

In 1913, I carried on whaling operations from Magdalena Bay, Lower California. At the end of October the blue whale came from the north and proceeded southward along the shore. Then in April, May, and June it came northward again.

Each winter and spring season from 1924/25 to 1938/39, and again in early 1935, one or two floating factories operated mostly from Bahia Magdalena, but also from other points along the west coast of Mexico. Between Cabo San Lucas and Isla Cedros, Baja California, these expeditions took 47 to 239 blue whales each season, and a total of 269. Since then blue whales have not been exploited off Baja California.

During our whale marking cruises we found blue whales along the entire west coast of Baja California, from  $23^{\circ}15'N$  latitude to  $32^{\circ}05'N$

latitude. We also saw two east of Isla Cerralvo on the west side of the mouth of the Gulf of California on 8 February 1966, and on moving north midway between Cabo San Lucas and the Islas Tres Marias on 16 February 1967. All of the blue whales that we observed were less than 80 km from shore, some only 3 km. Many were in shallow water between 50 m and 200 m deep.

Small numbers of blue whales were taken off Baja California in October, but catches were practically nil from November through January. The catch statistics and our observations show that the major influx of blue whales begins in late February, the greatest numbers are present in April, and that departure is nearly complete by early July.

The whereabouts of these blue whales during the remainder of the year, and their relation to populations on whaling grounds farther north, is problematical. During the 1965 whale marking cruises, we effectively marked 49 blue whales—26 in February and March, and 23 in June. None of these marks was recovered during the 1965 whaling season. These negative results are inconclusive. Killing of blue whales has been banned in subsequent seasons.

Although the blue whales are gone from Baja California waters by late June or early July, they usually do not show up off central California until late September. If they head north upon leaving Baja California, they must pass central California far offshore. In May 1963 Berzin and Novmin (1966) observed blue whales migrating north at  $41^{\circ}$  to  $42^{\circ}N$  latitude,  $130^{\circ}W$  longitude, off the coast of northern California. Catches off Vancouver Island show two peaks of abundance, in June and September.

In more northerly waters, pelagic whaling has revealed three major summer concentration areas for blue whales: (1) the eastern Gulf of Alaska, from  $130^{\circ}$  to  $140^{\circ}W$  longitude; (2) the area south of the eastern Aleutians, from  $160^{\circ}$  to  $180^{\circ}W$  longitude; and (3) the area from the far western Aleutians to Kamchatka,  $170^{\circ}$  to  $160^{\circ}E$  longitude. Catches in the eastern Aleutian area show a peak in June, whereas those in the Gulf of Alaska show a peak in July. This difference tends to support Berzin and Novmin's (1966) hypothesis that some of

the northbound migrants turn west at about  $50^{\circ}\text{N}$  latitude and proceed directly to the eastern Aleutians, while others continue north along the coast into the Gulf of Alaska. Out of 15 Japanese and Soviet recoveries of blue whales marked on the summer grounds, five demonstrated movement between the three major areas noted above; one whale even moved from the eastern Okhotsk Sea to the Gulf of Alaska (Ivashin and Rovnin 1967; Anon. 1967). The remaining 10 whales were recovered in the area where they were marked.

From the above facts I postulate that the majority of this stock of blue whales leaves Baja California waters in May and heads north, passes central California far offshore, and arrives on the whaling grounds off Vancouver Island in June. From there at least some must proceed to the eastern Aleutians or into the Gulf of Alaska. They leave the latter areas in August and pass Vancouver Island in September, central California in late September and October, and Baja California in October. There are no data on their movements from November through January, but they must be either farther offshore or farther south. Our observation of a northbound animal north of the Islas Tres Marias in February gives a little support to the second alternative.

**Population.** The catch of blue whales off Baja California from 1924/25 to 1928/29 averaged 180 per year. The catch per unit of effort (gross number of catcher's day's work) showed no downward trend. During the same five-year period, blue whale catches in California, British Columbia, and Alaska averaged 101 per year. Annual catches fluctuated but showed no downward trend; in fact, an upward trend is suggested, even though effort remained about constant. During this period the population of blue whales in the eastern North Pacific as a whole apparently sustained an average kill of 289 animals per year. To do this would require a total population of about 6,000 animals, since the recruitment can hardly have been greater than 0.05. Aside from this five-year period in the late 1920's no single year's catch has ever exceeded 271, except for a catch of 440 in 1963. In 1964 Doi, Nemoto, and Ohsumi (1967) calculated that the summer blue whale populations in the three main pelagic whaling areas had dropped to about 3,420 from a postwar initial stock of about 2,430. This estimate

did not include populations east of  $140^{\circ}\text{W}$  longitude.

The above data suggest that blue whales were never very abundant in the eastern North Pacific, and their population size has not decreased very markedly.

Off Baja California I have seen blue whales among—and possibly feeding on—schools of pelagic red crabs, *Neuroncodes planipes*, which are often abundant in the inshore waters. Although there is not a very marked seasonal variation in the abundance of these crabs, the presence of the blue whales does coincide with the period of greatest crab abundance (Longhurst 1967).

Since this seasonal aggregation of blue whales takes place close to the overpopulated megalopolis of southern California, it offers an opportunity for commercial whale-watching cruises. Cruises to observe gray whales and seal rookeries are already a rapidly growing business in this area. It is probably the only place in the world where the average citizen has a fair chance of seeing a live blue whale with a reasonable expenditure of time and money.

#### Fin Whale (*Balaenoptera physalus*)

**Distribution.** The winter grounds of fin whales in the southeastern North Pacific, as elsewhere in the world, remain very poorly known. We have found fin whales from  $15^{\circ}30'\text{N}$  latitude off the Big Sur coast of California south to  $22^{\circ}50'\text{N}$  latitude west of Cabo San Lucas, Baja California. The only area where they were encountered repeatedly in any numbers was west of the Channel Islands off southern California. Although we saw none far offshore, many must spend the winter out at sea, because the number observed in the immediate offshore waters is insufficient to account for the entire eastern North Pacific population. On 20 May 1966 Kenneth C. Balcomb (personal communication) observed 8 to 12 fin whales in the mid-Pacific at  $17^{\circ}54'\text{N}$  latitude,  $158^{\circ}46'\text{W}$  longitude, and Berzin and Rovnin (1966) reported some at  $37^{\circ}\text{N}$  latitude,  $130^{\circ}\text{W}$  longitude in February 1964. In the summer fin whales range in the immediate offshore waters around the North Pacific, from Chukchi Sea southward along the Asian side to Japan, and along the American side to southern California and sometimes central Baja California.

Eight fin whales that we marked in the winter (November to January) off southern California were recovered in the summer (May to July) off central California (one), Oregon (four), British Columbia (one), and in the Gulf of Alaska (two).

Off central California the pattern of seasonal changes in the abundance of fin whales varies from year to year, but a general pattern is evident. Numbers reach a peak in late May or early June, after which they fall off. There is usually a second influx later in the summer, which is more prolonged and more variable in its timing than the early peak.

**Population.** During their first two years of operation (1956 and 1957), the California catcher-boats did not go far enough offshore to find many fin whales, because humpback whales were so abundant closer inshore. By 1958 the increasing scarcity of the latter species forced the whalers to turn their attention to fin whales. Although the catch fluctuated considerably from year to year, there was an overall downward trend in catch per gross catcher's day's work from about 0.14 in 1958 to 1960 to about 0.06 in 1968 to 1970, a reduction of about 57% (Table 6-4). This figure agrees with Ohsumi, Shimadzu, and Doi's (1971) estimate that the entire eastern North Pacific stock of fin whales decreased by 55% during this period, from about 20,000 to 9,000 recruited animals. This stock is well below the level of maximum sustainable yield.

#### Sei Whale (*Balaenoptera borealis*)

**Distribution.** The winter distribution of sei whales is even less known than that of fin whales. We found sei whales widely but sparsely scattered from  $35^{\circ}30'N$  latitude off Point Piedras Blancas, California, south to  $18^{\circ}30'N$ , 600 km offshore in the vicinity of the Islas Revillagigedo. Nowhere did we find them regularly or in any numbers. Perhaps the majority spend the winter in far offshore waters.

The summer distribution of sei whales is similar to that of fin whales, except that they rarely go north of the Aleutian Islands. Off our coast they range south to the area west of the California Channel Islands, and we saw one at  $27^{\circ}13'N$ , off Baja California.

TABLE 6-4. Scaled whale catch (C) and catch per unit of effort (C/E) at California shore stations, 1956-1970.

Year	Gross number of catcher's day's work	Blue		Fin		Sei		Humpback	
		C	C/E	C	C/E	C	C/E	C	C/E
1956	317	0	0	3	0.010	0	0	133	0.420
1957	505	0	0	22	0.044	1	0.002	199	0.394
1958	703	26	0.037	109	0.155	2	0.003	115	0.164
1959	920	5	0.025	108	0.116	37	0.040	140	0.152
1960	915	1	0.001	138	0.151	47	0.051	67	0.073
1961	915	2	0.002	118	0.129	51	0.056	62	0.068
1962	915	2	0.002	123	0.134	22	0.024	39	0.043
1963	915	6	0.007	17	0.019	96	0.105	55	0.060
1964	915	2	0.002	148	0.164	13	0.014	27	0.030
1965	871	4	0.005	114	0.131	22	0.025	4	0.005
1966	*	787		42	0.053	62	0.078		
1967	549			44	0.080	3	0.005		
1968	421			38	0.090	14	0.033		
1969	332			31	0.058	10	0.019		
1970	368			5	0.014	4	0.011		

Off central California sei whales are usually present only during the late summer and early autumn. In some years a few arrive in late May or June, but in most years they do not show up until early July.

One sei whale that we marked off southern California in November 1962 was killed off Vancouver Island in August 1966. Another, marked in the same general area in June 1965, was killed about 1200 km off the Washington coast in July 1969.

**Population.** As with fin whales, the California whalers made no real effort to take sei whales until 1949, after the humpbacks had been depleted. Since that year the sei whale catches have fluctuated more than the fin whale catches, but there has been a similar overall downward trend in catch per unit of effort from 0.05 in 1959 to 1961 to 0.02 in 1968 to 1970, a reduction of 60% (Table 6-4). Ohsumi, Shimadzu, and Doi (1971) estimated that the eastern North Pacific sei

whale stock decreased from roughly 40,000 to 28,000 recruited animals during this period, but that the stock was still at or above the level of maximum sustainable yield.

Seven percent of the sei whales taken off central California have been infected with a unique disease that results in the progressive shedding of the baleen plates and their replacement by an abnormal papilloma-like growth. In one case all baleen plates were missing. The epidemiology and etiology of this disease are unknown, but the collecting of two afflicted whales from one pod suggests that it is contagious. Histological studies revealed the presence of tiny granular structures that resemble *bedsonia* (*Chlamydia* sp.). Attempts by the Naval Biological Laboratory in Oakland to isolate the causative agent were unsuccessful. The loss of such a highly specialized feeding apparatus as the baleen plates would appear to make it impossible for a whale to feed. Yet none of the diseased animals appeared emaciated and most had anchovies (*Engraulis mordax*), sardines (*Cololabis saira*), or jack mackerel (*Trachurus symmetricus*) in their stomachs; none had euphausiids or copepods. Healthy sei whales feed on crustaceans as well as fish. The ultimate effects of this disease are unknown. Because of its high incidence and severity, it might cause significant mortality. Strangely enough, this disease has never been found in sei whales elsewhere in the world, nor in any other species of whale, with the possible exception of an Antarctic fin whale (*Tomolinnus macrourus* 1968).

Sei whales are also much more prone to heavy infestations of parasitic helminths than are other baleen whales. The liver fluke *Iecithodamnus spinosus* causes hardening of the tip of the liver. The stomach worm *Anisakis simplex*, although usually abundant, is not normally pathogenic. In one case, however, many worms had invaded the liver, which was undergoing pathological degeneration. Perhaps both these helminths sometimes kill the host.

#### Snyder's Whale (*Balaenoptera adamsi*)

**Distribution.** On the west coast of Baja California, Snyder's whales inhabit the inshore waters from  $26^{\circ}12'N$  latitude south to Cabo

San Lucas. They also range all across the southern end of the Gulf of California north, at least as far as we went, to  $25^{\circ}40'N$  latitude on the western side and Mazatlán, Sinaloa, on the eastern side. Robert L. Brownell (personal communication) found a stranded specimen in the northern gulf. We saw a few as far south as the Islas Tres Marias.

Snyder's whales appear to be year-round residents in these waters, as we encountered them on two cruises in June and September as well as during the winter and early spring cruises.

**Population.** Until recent years, Snyder's whales were not distinguished from sei whales in the International Whaling Statistics. The floating factories that operated on the west coast of Mexico in 1911/14, 1924/25 to 1928/29, and 1935 reported taking 121 "sei" whales between Bahía San Juanico, Baja California, and the Islas Tres Marias, Nayarit. Because sei whales are scarce in this area, whereas Snyder's whales are common, I believe that most if not all of the animals reported as "sei" whales were probably Snyder's whales. Indeed, the companies' daily catch records for 1925/26 list some of them as "Snyderwhal" or as "sei (Snyderwhal)," and all 14 whales taken that season that were reported as sei whales in the International Whaling Statistics were reported as Snyder's whales by Kellogg (1931) and Radcliffe (1933).

This stock of whales has not been exploited since 1935 and may be assumed to be at the carrying capacity of the area. Insufficient data are available to make a quantitative assessment.

#### Kinke Whale (*Balaenoptera acutorostrata*)

**Distribution.** During the winter we have found kinke whales widely spread all the way from central California south to the Islas Revillagigedo. They are most abundant in the vicinity of the Channel Islands off southern California.

In the summer they occur from at least as far south as  $36^{\circ}45'N$  latitude off Baja California, north to the Chukchi Sea. They are fairly common off central California, but are much more abundant in Alaskan waters. A sizable population inhabits the inside waters of Puget Sound.

has never been attempted in the eastern North Pacific as it has off Norway and Japan. The eastern North Pacific population of minke whales is probably at the carrying capacity, but there are insufficient data for a quantitative assessment of its size or sustainable yield. In recent years pelagic expeditions in the Antarctic and one shore station in South Africa have taken significant numbers of minke whales because of a scarcity of larger species of baleen whales.

#### Humpback Whale (*Megaptera novaeangliae*)

**Distribution.** During the winter months, most humpback whales congregate in warm waters close to continental coastlines or oceanic islands. Their distribution at this season in the eastern North Pacific is well known from the logbook records of the nineteenth-century American whaleships, the catch records maintained by the floating factories that operated off Mexico in the 1920's and 1930's, and our observations during the past decade. These winter grounds include three somewhat discrete areas:

- (1) The west coast of Baja California, chiefly from Isla Cedros south to Cabo San Lucas, and around the cape at least as far north as Isla San José. A few may also be found at this season farther north along the west coast as far as Ensenada, and rarely to southern California.
- (2) The mainland coast of west-central Mexico, from southern Sinaloa to Jalisco, especially in the vicinity of the Islas Tres Marias and Isla Isabela, Nayarit, and Bahía Banderas, Jalisco.
- (3) The far offshore Islas Revillagigedo, including Isla San Benedicto, Isla Socorro, and Isla Clarida.

Humpback whales also winter around the main Hawaiian Islands. I observed some off Oahu in February 1966. According to Kenneth S. Norris (personal communication), they are regularly seen around the main islands.

In the western North Pacific, humpback whales are known to winter around the Mariana Islands, around the Bonin Islands, and from southern Honshu, Kyushu, and South Korea southwest through the Ryukyu Islands to Taiwan (Omura 1950; Nishiwaki 1959).

Humpbacks occur all summer off central California. From there, their summer range extends around the entire North Pacific in the immediate offshore waters as far as Japan, and north through the Bering Sea into the Chukchi Sea.

Migration of humpback whales between summer grounds in the eastern Aleutians and the winter grounds in the Ryukyu and Bonin Islands has been demonstrated by eight Japanese mark recoveries (Onon 1967). Although none of the 28 humpbacks that we marked off California and Mexico from June 1963 to June 1965 had been recovered by the end of the 1965 whaling season (after which the hunting of humpbacks was banned), it is probable that some of the humpbacks that winter in this area migrate far enough north to mingle with the western Pacific stock on the summer grounds.

**Population.** Because of their coastal habits, humpback whales are particularly vulnerable to exploitation by shore stations. Off Baja California, the number of humpbacks killed per gross catcher's day's work dropped steadily from 0.41 in 1924/25 to 0.03 in 1928/29, a 93% reduction. Off central California, the number dropped from 0.42 in 1936 to 0.005 in 1965, a reduction of almost 99% (Table 6-4). Decreases were also apparent in the catches at the Alaskan shore stations that operated in prewar years, and at the British Columbia stations in both pre- and postwar years. By the early 1960's the only area remaining in the North Pacific where large numbers of humpbacks congregated in the summer was around the eastern Aleutians and south of the Alaska Peninsula, from  $150^{\circ}$  to  $170^{\circ}\text{W}$  longitude. Large pelagic catches in that area in 1962 and 1963 reduced the population to an estimated 2,100 (Doi, Nemoto, and Ohsumi 1967). An additional 588 humpbacks were killed in 1964 and 1965. The remaining population probably represents the bulk of both the eastern and western North Pacific breeding stocks.

We made a survey over the entire eastern North Pacific winter grounds between 26 January and 15 March 1965, a time of year when the majority of the animals should be there. Our two vessels spent a total of 68 days cruising; we encountered only 33 groups of humpbacks, totaling 102 individuals: 10 on the west coast of Baja California,

65 along the coast of southern Sinaloa, Baja California, and Jalisco, and 27 around the Islas Revillagigedo. More recent but less extensive cruises revealed similar numbers. It is difficult to extrapolate these counts to obtain an estimate of the total population on the winter grounds. Since humpbacks concentrate in coastal waters during the winter, I believe that we saw a fairly large proportion of the population. If so, the entire eastern North Pacific stock now numbers only a few hundred individuals.

Gray Whale (*Eschrichtius robustus*)

Distribution. The migrations of the eastern Pacific stock of gray whales between their Arctic summer grounds and their Mexican winter grounds is well known and has been summarized most recently by Rice and Wolman (1971).

Population. In the winter of 1969/70 we estimated that the population size was around 11,000 and had remained stable since 1967/68 (Rice and Wolman 1971). The 1970/71 census yielded an estimate almost identical with those of the preceding three years.

Black Right Whale (*Eubalaena glacialis*)

Distribution. The "Kodiak Ground," which encompassed the entire Gulf of Alaska from Vancouver Island to the eastern Aleutians, was renowned in the nineteenth century as one of the best areas for hunting right whales during the summer. At that season a few could be found in the southern Bering Sea and all across the North Pacific above 50°N latitude.

Their winter grounds have been somewhat of a mystery (Scammon 1874). In other parts of the world the females with calves resort to coastal bays in the winter, but none has ever been found doing so in the eastern North Pacific. Only a few right whales have been found during the winter and spring months off the west coast—some as far south as Punta Abreojos, Baja California.

Population. The nineteenth-century American whalers almost succeeded in completely exterminating the right whale in the eastern North Pacific. How close they came is apparent from the fact that from 1905, when modern whaling methods were introduced on the west

coast, to 1937, when right whales were given legal protection, only 24 were killed by the whaling stations in Alaska and British Columbia. Onoza, Ohsumi, Nemoto, Nasu, and Kamiya (1969) have summarized recent sightings on the summer grounds, and Pike and MacKinnie (1969) reported several sightings off British Columbia. Rice and Finsen (1968) reviewed the status of right whales in the southeastern North Pacific. The lack of any additional sightings since then further confirms our opinion that this stock numbers only a few individuals and has not noticeably increased in the past 35 years.

Bowhead Whale (*Balaena mysticetus*)

Distribution. Bowheads spend the winter in the loose, southern edge of the pack ice, which usually extends across the central Bering Sea from Kuskokwim Bay, Alaska, west-southeast to the northern shores of the Kamchatka Peninsula, USSR.

As soon as the ice north of the Bering Strait begins to break up in the spring, the whales migrate northward through the open leads. Many follow the shore lead (between the fast ice and the pack ice). The first whales pass Point Hope, Alaska, in early April, and Point Barrow in late April. In the summer they are distributed in the shallow waters of the northern Bering Sea, the Chukchi Sea, and the Beaufort Sea east to about Banks Island. During the autumn freeze-up, they retreat south of the Bering Strait.

Population. American whaling ships first went through Bering Strait into the Arctic Ocean in 1848. From 1868 on, the Arctic Ocean was the principal resort of the North Pacific fleet. In 1870 the fleet reached a peak of 53 vessels that took about 487 bowhead whales (estimated on the basis of whalebone production). Starting in 1884, many shore whaling stations were established in northwestern Alaska by white men who employed Eskimos. Many writers have stated, without documentation, that the bowhead whale population was greatly reduced during this period. The statistics show that during the peak of the fishery, from 1868 to 1884, the catch per vessel fluctuated but showed no downward trend. An estimated average of 219 whales was killed each year (excluding 1871 and 1876, when most of the fleet was lost

in the ice). If the population was stable, the fishery mortality could hardly have exceeded 5%, so the population may have been around 4,000 or 5,000. The fishery collapsed when the bottom fell out of the whalebone market after 1909.

The maritime Eskimos of Arctic Alaska have hunted bowhead whales for perhaps 50 centuries. Today the Eskimos living in the villages of Point Hope, Barrow, and Wainwright hunt whales each year during April and May. Temporary camps transported by dogsled are established at the edge of the fast ice. The whales are chased in easily transportable skin-covered umiaks, about 6.6 m long, propelled with paddles. The only major innovation since prehistoric times is the adoption of darting-guns and shoulder-guns which fire bomb-lances. Formerly, bone-headed harpoons were used. An annual average of about 10 bowheads are killed and recovered. For each whale recovered about 3 or 4 are struck and lost; some of these may die, so the total number of whales killed off Alaska is probably about 20 per year. Bowheads are rarely killed off Siberia (Simszuk 1969). Catch statistics for Barrow since 1938, compiled by Maher and Willmovsky (1963), and for Point Hope since 1930, compiled by the late Don C. Roots (personal communication), give no indication that the population size has changed during this century. These facts imply a minimum population of about 400.

Each year between early April and early June, between 100 and 200 whales are observed migrating past Point Hope and Barrow. The highest rate of migration that I observed was at Point Barrow on 11 May 1952, when 25 whales passed during the 23-hour period from 0030 to 2330 hours. These counts are made only during periods when the whaling camps are occupied; whaling is suspended when the shore lead closes, and when it becomes more than 2 km wide. In the early part of the whaling season it may be too dark to see whales during the midnight hours, but often they can be heard blowing. Many more whales pass too far offshore to be seen from the fast ice. Pilots flying for the Arctic Research Laboratory at Barrow told me that they have seen bowheads in leads and polynyas as far as 80 km offshore in May. The number of whales observed from the whaling camps is thus only a small proportion of the total population.

*Sperm Whale (*Physeter catodon*)*

Distribution. During the winter, sperm whales are scattered across the entire North Pacific below 40°N latitude. From November through April we have frequently encountered breeding schools over the continental slope off the coast of California from 33° to 38°N latitude. South of California, except for two large bulls at Isla Guadalupe, we encountered sperm whales only in the area south of Cabo San Lucas and west of the Islas Tres Marias. Many were taken the year round in the latter area in the nineteenth century, but we found only a few, all males. The old records also indicate that the area around the main Hawaiian Islands was a year-round concentration area.

During the summer, sperm whales may be found anywhere in the North Pacific. The area of greatest population density extends from the southwestern Bering Sea and northern Gulf of Alaska south to 50°N latitude, dipping to below 40°N latitude on the American coast. Other major summer grounds lie between 25° and 35°N latitude from 180° longitude west to Japan, and then no northward along the entire Asiatic coast.

The summer range of the population that winters off California is indicated by the recovery of three whales that were marked off southern California in January. These included a male taken off northern California in June, an animal of unknown sex off Washington in June, and a female in the western Gulf of Alaska in April.

On the whaling grounds off central California sperm whales are common from early April until the middle of June, reaching a peak in mid-May. They are again common from the end of August to the middle of November, reaching a peak in mid-September. Very few are present in mid-summer. We found no sperm whales between San Francisco and Bahia Magdalena during cruises in May, June, and September. The two annual peaks of abundance suggest that the whales are moving north through the whaling grounds off San Francisco in the spring and are returning south in the autumn.

Japanese and Soviet mark recoveries reveal considerable longitudinal dispersal of sperm whales. The mating season extends from late winter to late summer, so a female might mate almost anywhere within her year-round range. Furthermore, the harem bulls apparently

do not remain long in a particular breeding school. These facts suggest that all North Pacific sperm whales comprise one widely interbreeding population.

**Population.** During their first five years of operation (1956 to 1961), the California whaling stations took sperm whales only when they could not find baleen whales. In 1962 there was a sharp rise in the price of sperm oil, and baleen whales were becoming less common, so the whalers expended more effort on sperm whales. Since the data are inadequate to determine the number of catcher's day's work spent hunting sperm whales, I have used simply the catch per vessel per season as a measure of the abundance of legal-sized male sperm whales (Table 6-5). The catch per boat averaged 12.6 from 1961 to 1965.

TABLE 6-5. Male sperm whale catch, effort, catch per unit of effort, and mean body length, at California shore stations, 1956-1970.

Season	Catch of male sperm Whales <sup>a</sup>	Number of catcher-boats	Whales per catcher-boat	Mean body length <sup>b</sup>
			Feet	Meters
1956	9	2	4.5	43.2
1957	14	3	4.7	44.4
1958	8	4	2.0	45.7
1959	17	5	3.4	42.6
1960	14	5	2.8	44.7
1961	59	5	11.8	42.0
1962	46	5	9.2	41.4
1963	75	5	15.0	41.4
1964	54	5	10.8	39.6
1965	82	5	16.4	40.8
1966	37	5	7.4	40.5
1967	29	3	9.7	41.1
1968	23	3	7.7	38.7
1969	21	3	7.0	40.4
1970	20	3	6.6	40.1
				12.23

<sup>a</sup> Excluding whales taken on special scientific permits, 1966 to 1970.

<sup>b</sup> Excluding whales less than 34.5 ft (10.52 m) long taken on special scientific permits, but including whales longer than 34.5 ft taken out of season on permits.

thereafter it dropped and reached a low of 6.6 in 1970. The mean body length of legal-sized males in the catch dropped from 44.0 ft (13.42 m) during 1956 to 1960 to 39.7 ft (12.11 m) during 1968 to 1970. This decrease in the availability of adult males off California agrees with Ohsumi, Shimadzu, and Doi's (1971) calculation that the recruited stock of male sperm whales in the entire northern North Pacific dropped from 134,000 in 1964 to 64,000 in 1970.

From 1956 through 1965, only 18% of the sperm whales killed off California were females. From 1966 through 1970, when special scientific permits allowed the taking of animals shorter than the legal minimum length, 53% of the catch was females. In the North Pacific as a whole, females make up about 25% of the catch, and the number taken has never been so high as the estimated sustainable yield (Ohsumi, Shimadzu, and Doi 1971).

#### Giant Bottlenose Whale (*Hyperoodon ampullatus*)

**Distribution.** This species is endemic to the North Pacific. It ranges from St. Matthew Island in the Bering Sea south in the eastern Pacific to 32°30'N latitude off southern California, and in the western Pacific to 34°00'N off Japan.

Seasonal movements are poorly understood. California catches suggest two peaks of abundance, in July and October. Off British Columbia, the majority have been killed in August.

Thirteen of 15 (87%) taken off California were males. Likewise, off British Columbia, 93% of those killed were males (Pike and MacAskill 1969), and in most areas of Japan males predominate in the catch (Omura, Fujino, and Kimura 1956). Since females average larger than males, the preponderance of males in the catches in certain areas suggests a partial geographical segregation of the sexes.

**Population.** Although bottlenose whales are regularly encountered off central California, they are not common there. Because of their relatively small size, whalers in the eastern North Pacific rarely bother to kill them. Only 15 were taken off California from 1956 to 1970, and 29 off British Columbia from 1953 to 1967.

## Summary and Conclusions

The cetacean fauna of the eastern North Pacific includes 11 species of "large" whales—here defined as species that attain a body length greater than 9 meters. Included are 9 of the world's 10 species of baleen whales (order Mysticeti) and the two largest species of toothed whales (order Odontoceti). Seven of these species are virtually worldwide; these include the sperm whale, the black right whale, and all the rorquals (family Balaenopteridae) except Bryde's whale, which is more or less circumtropical in coastal waters. Two species, the gray whale and the giant bottlenose whale, are endemic to the North Pacific. The bowhead whale is restricted to Arctic waters.

Since baleen whales are more abundant in the highly productive coastal waters, and most species migrate annually between higher latitude summer feeding grounds and lower latitude winter breeding grounds, the eastern North Pacific stocks of each species are probably more or less discrete from the western North Pacific stocks. More data are required to delimit stock units of toothed whales.

From the standpoint of their conservation, the species of large whales may be divided into three categories: (1) legally protected species whose population sizes are (or were) small; (2) species that are currently taken commercially; and (3) species that have remained virtually unexploited.

Five species of large whales are now afforded complete protection from commercial whaling by the 1946 International Convention for the Regulation of Whaling. The black right whale was formerly abundant in the eastern North Pacific, but was so heavily exploited in the nineteenth century that its population was reduced to perhaps no more than a few dozen individuals and has not noticeably increased since. The humpback whale, also formerly abundant, has been reduced in recent years to only a few hundred individuals. The blue whale population probably numbers no more than 2,000, but never was very great. The bowhead whale population does not appear to have been seriously reduced by nineteenth-century exploitation, but it numbers only a few thousand at most in its limited Arctic range. The gray whale population, much reduced in the nineteenth century, has greatly increased and is now

stable at about 11,000. A few bowheads and gray whales are killed by Eskimos.

Three species are currently being exploited commercially in the eastern North Pacific, under the regulation of the International Whaling Commission. The fin whale population has been reduced during post-war years by 55%, from about 20,000 to 9,000 recruited animals (that is, animals of legally harvestable size), a number well below the optimum size. The sei whale population has been reduced during the same period by 10%, from about 40,000 to 36,000 recruited animals, which is about the number that will produce the maximum sustainable yield. The sperm whale stocks in the eastern and western North Pacific probably comprise one interbreeding population that may number several hundred thousand; during the past decade the number of legal-sized males (> 10.5 m long) has been reduced by 50%, but females have been underharvested.

Three species have been virtually unexploited in the eastern North Pacific, and their population sizes are unknown. These species are the Bryde's whale, the minke whale, and the giant bottlenose whale.

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